but the reader expects also a presentation in vivid style of the imagination and enthusiasm that Archimedes exhibited in the saying "Give me a fulcrum on which to rest, and I will move the earth;" the reader likes to be entertained by the narrative of his behavior when the true solution of the problem of the crown flashed on his mind—how he jumped out of his bath and shouted "I have found it"; the reader likes to be able to cite as marks of high patriotism his services to his sovereign in the construction of war engines and his alleged use of reflecting mirrors to set the Roman ships afire; the reader wishes to be reminded of the tragic death of Archimedes at the hands of a Roman soldier whom he had requested not to spoil his circles drawn in the sand, of his desire that the figure for his theorem on the sphere and circumscribed cylinder be inscribed upon his tomb, and how, over a century later, Cicero found the tomb of this the greatest mathematician of antiquity almost hidden amongst briars near one of the gates of Syracuse and forgotten by the people of the city.

Details of this sort do not strictly belong to a history of scientific ideas, but they add color to the narrative. Like all men, the mathematical reader is largely dominated by feeling. A modern poet has said of Horace,

> It is a curse
> To understand, not feel thy lyric flow,
> To comprehend, but never love thy verse.

Where is the science which appeals to the intellect alone, never to the heart? Such a science, if it exists at all, can not be found in the camp of the mathematicians. Certainly, then, the history of mathematics should appeal to the heart as well as to the head. Such a history should create respect and love for mathematics; it should excite admiration for this science; it should make the mathematician feel stronger than ever that he is contributing his bit toward the true grandeur of nations.

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THE BRITISH NATIONAL PHYSICAL LABORATORY

The National Physical Laboratory is now conducted as a government institution under the financial control of the Committee for Scientific and Industrial Research, though its scientific work and researches remain under the direction of the Royal Society as before, and its annual report, of which the London *Times* gives an abstract, is for the first time published by the Stationery Office (2s. 6d. n.). As has been the case since 1914, a large part of the laboratory's work last year was in connection with the requirements of the war, and therefore can not be described in detail, even if referred to at all, but there is a considerable body of investigations to which this limitation does not apply.

In the electrical department additional magnetograph 24-hour records were taken and coincidences found between the running of electric trains on the London and South-Western Railway and magnetic disturbances at the laboratory. The question as to the magnitude and cause of certain of the disturbances was submitted to the arbitration of Mr. A. J. Walter, K.C., in November and December, and he adjudged that the use of electrical power by the railway has caused an increase in the horizontal magnetic field at the laboratory to an extent exceeding that stipulated in the South-Western Railway Act of 1913.

Among general electrical measurements a large number of the small mica condensers used in magnetos were tested for capacity and power factor; much work was done in connection with the composition and treatment of steel used for compass needles, and some special search coils proved valuable in testing permanent horse-shoe magnets. Some investigation was also made of the properties of non-magnetic steels. Sensitive vibration galvanometers for frequencies of the order of 10 cycles were constructed, and some preparations made for a research on effective resistance at radio frequencies. A new 400-volt secondary battery is being installed for use with large valves to generate the high-frequency current.

In the division of electrotechnics, in view of

the fact that large gas-filled lamps cause considerable heating of the lamp sockets used with them, owing to conduction of heat from the bulbs, measurements were made of the temperature rise of ventilated and unventilated sockets, and of the leading-in cables when used in lanterns of both the open and the enclosed types. It was found that the cables were liable to a total temperature of about 140° C., and that little improvement resulted from the use of existing arrangements for socket ventilation.

Good progress was made with the research on buried cables. The electrical constants of all the cables under test were determined, and it was found that in general the rise of temperature of a cable drawn into a stoneware duct was twice that of a similar cable armored and laid direct in the ground, cables laid solid in bitumen occupying an intermediate position. Other points, such as the length of time required by the cables to attain their maximum temperature, the effect of the ends, and the temperature gradient in the duct and in the cable, were also dealt with. The design of the special motor-generator set which will be used to supply continuous current for the cables, and which will also be used for heavy test work, has been settled and the machine is under construction. It consists of two continuous-current generators, each fitted with two commutators. Each commutator is arranged for a current of 1,250 ampères at 6 volts, the ends being brought to a series-paralleling board. By this means currents up to 1,250 ampères at 24 volts will be available for the cable tests and up to 5,000 ampères at 6 volts for the test work, suitable regulation to any required current being obtained by resistances in the exciting circuits. The generators, which will be driven by a three-phase 3,000-volt motor running off the town supply, will be separately excited, the excitation current being maintained constant by a centrifugal spring regulator putting resistance into or out of the field of the motor.

The heat division collaborated with the Heating and Cooking Panel of the Engineering Standards Association in developing efficiency tests for electrical plates and cooking stoves. A number of pyrometer sheaths of British manufacture were tested for their softening point and porosity at high temperature. Some of the samples of porcelain, though unglazed, stood the porosity test remarkably well; in fact, when the interior was exhausted to a pressure of a few millimeters of mercury the walls collapsed under the external pressure before any leakage occurred. On the other hand, tubes of fireclay and shrunk alumina often showed a return to atmospheric pressure in about 10 seconds. A large series of aluminium alloys was investigated for thermal conductivity on behalf of the Light Alloys Sub-committee of the Advisory Committee for Aeronautics, the advantages of such alloys, on account of their high conductivity, for the construction of the cylinders and pistons of aero engines having been appreciated for some time. It was evident at the outset that measurements at room temperature would not be sufficient, since the temperatures encountered in actual practise range up to 300° C., and an absolute and expeditious method of determining thermal conductivity and its variation with temperature was therefore devised.

In Metrology the year was distinguished by the development of the gauge-testing work. The new gauge-testing building was completed in May, and occupied in the early part of June. The numbers dealt with, however, continued to increase and at the end of 1917 were more than double those of 1916. There was a steady increase in the quantity of screw gauges tested, but in the first three months of this year there was a considerable reduction in gauges of the more simple types. The types that continue to be received are, however, in general more complicated and involve more work in testing than those which have dropped out. The gauge-rectifying shop was found much too small to meet the demands made upon it, and the erection of a new workshop of 10,000 square feet area was sanctioned. The building of this has been started.

Arrangements have been made for the calibration of glass volumetric apparatus. Accom-

modation for the work will be provided in a new three-story building to be erected alongside the Administration Building, but meantime a house close to the laboratory entrance is being equipped temporarily for the purpose.

A watch sent for testing by Paul Ditisheim, La Chaux de Fonds, Switzerland, obtained 96.2 marks out of a possible 100—the highest total yet recorded in the Kew trials.

The investigations of the methods of notched bar impact testing were continued, and in the present year it is proposed to inquire into the following questions: Need for test bars of different sizes; the question of test bars supported at two ends or fixed at one end; how far the work of fracture depends on the cross-section or the volume of the test bar, or both, and whether a relation can be found for reducing results on one size of bar to those on another; influence of the velocity of striking and angle of bend of the bar; and application of notched bar tests to carbon steels in industrial products. The hardness test research is being extended to cover the effect of the wear caused by sliding abrasion, of variations in the relative velocity of the surfaces, and of the pressure between them. The Brinell ball test, usually adopted for indicating the indentation hardness of a material, is open to the objection that it varies with the load and with the hardness of ball used. Hence a standard ball of 10 mm. diameter and a fixed load of 3,000 kg. are employed, but it is not always possible to use this standard—*e. g.*, with very thin test pieces or very soft materials. Experiments have therefore been made with the object of studying the various methods of bringing results obtained with different balls and loads into line with those obtained by using the standard.

The experiments with the apparatus described in last year's report for determining the heat transmission to water from the internal surfaces of brass pipes, smooth and roughened, were completed. The results showed that, with the amount of roughening obtained, the heat transmission per unit surface per degree in difference of temperature between metal and water for the smooth pipe could be increased in the ratio of about 2.5 to 1 for the same mean velocity of flow. It was obvious that if improvements of this order could be made in the surfaces of air-cooled engines and radiators, considerable economy of material could be effected in aeroplane engine design. To test the question a series of copper gills of the form and distribution commonly adopted in air-cooled engines was fixed to the cylinder of the engine and set up in a wind channel. An electric current was then circulated through the gills, and from measurements of the current and resistance it was possible to ascertain the temperature of the gills and the heat dissipated. The gills were first tested in their ordinary smooth condition and then roughened by means of corrugated steel dies. The roughening, however, appeared to produce practically no effect on the heat transmission, this result indicating that the convection of momentum to the rough and smooth surfaces was approximately the same. The reason for this apparent discrepancy between the two sets of observations is still under investigation.

The demands of the Aerodynamics Department are so numerous and important that the erection of two new air channels has been called for. A new airscreen balance for the 7 foot tunnel is in hand and a new apparatus for lift measurement is in use. Modified apparatus for the measurement of rotary derivatives was devised and will be further developed.

The research work carried out was of the most varied character. Tests were made on models of aeroplane wings, monoplane and biplane models of complete aeroplanes, airships and kite balloon models, and models of airscrews, with calculations relating to stability, strength of construction, bomb-dropping, etc. A large amount of work was done in connection with the design of wind channels, and the research on eddy motion was continued. Many of the investigations were made in response to direct requests from the Air Ministry, but every effort was made to increase the value of special tests by bringing them into proper relation as part of an organized scheme of research.

Such increase in equipment as was made in the Metallurgy Department arose chiefly in connection with the extension of foundry facilities urgently needed for the work on light alloys and on optical glass. The investigation on aluminium and other light alloys was energetically pursued and was devoted to the immediate requirements of aircraft construction. A considerable amount of theoretical investigation was also carried on, leading to the establishment of a number of constitutional models of ternary alloys of aluminium with other metals. A number of important practical questions were thus cleared up, among them being the explanation of the various forms in which silicon is found analytically in aluminium alloys and the bearing of these results on the properties of the materials. Other researches had for their object the elucidation of apparently anomalous behavior in various groups of aluminium alloys. The nature and constitution of the more important ternary alloys and the influence of impurities on them were investigated, with the result that these relationships are now much better understood.

A large amount of research and investigatory test work was carried out on steel. Some of the results obtained seem to be of wide importance in regard to the treatment to which particularly thick boiler plates can be safely subjected. Research on magnetic steels was actively continued. Investigation was begun of a set of specially made tungsten steels of graded composition, received from Messrs. Thomas Firth and Sons, but it was found necessary to adopt better methods of magnetic measurement than were used in the earlier stages of the work, and special arrangements were also made for carrying out thermal observations of these steels in a more satisfactory manner. A number of discrepancies were revealed, believed to arise from the influence which antecedent thermal and mechanical treatment of the steel exercises on its subsquent magnetic behavior. To clear up these questions, which are of vital importance in the production of satisfactory magnets, and which involve questions affecting steels other than the particular tungsten alloys under investigation, a special research was initiated for the study of the constitutional relations of iron-carbon-tungsten within the range of alloys concerned.

The work in connection with the proposed issue of standardized steel samples to serve as standards for the chemical analysis of steels was carried forward in conjunction with a committee of the Iron and Steel Institute, but was hampered by existing conditions. It is hoped however, that the issue of standardized samples may become possible shortly.

As regards optical glass a large amount of work was done in preparing pots or crucibles of special refractory materials that do not lend themselves to treatment by ordinary methods. Methods of melting and stirring glass were further investigated by means of experimental meltings, some of which gave results of great promise.

The testing of ship models for firms in the experimental tank was affected in two ways. First, the building of fast and intermediate liners being in temporary abeyance, there was no demand for model work with those types of vessel. Second, the introduction of standard vessels must result in the suppression of individuality in the forms adopted by different builders, and the model results for one firm will apply to all vessels of the type, no matter where built. It is therefore the more important that steps should be taken to ensure that whatever forms are adopted as standard shall be good ones. Private firms have recognized this, and about half the vessels tested for firms during the year were in connection with standardization. The best result obtained was a reduction of 13 per cent. in resistance without any variation of displacement or dimensions, or diminution of working qualities such as stability. Apart from tests for private firms a number of models of standard cargo vessels were made and tested for the Admiralty and others. There were a number of tests with straight line forms of fabricated ships, and the satisfactory results obtained must lead to an extension of the use of this type if it is found to be constructionally acceptable.